

SOIL

Soil forms the top layer of the earth's surface in which plants grow. Its function in the watershed is to allow precipitation to soak into the ground and replenish the groundwater.

The upper part of the soil, or unsaturated zone, has a combination of air and water in the spaces between the soil particles. The saturated zone occurs in the lower region of soil where all spaces are filled with water. The boundary between the two zones is called the water table (Janowicz, et. al, 1991).

As water infiltrates into the soil it is trapped between the soil particles. Porosity measures the amount of space between the soil particles. Large spaces occurring between sand grains can hold more water than the tiny spaces occurring between clay particles. Permeability measures how many of the spaces are connected. When many spaces are connected water flows quickly through the soil. When fewer spaces are connected water flows slowly through the soil (Emiliani, Knight, and Handwerker, 1989).

The following activities illustrate how water moves through the soil.



POROSITY AND PERMEABILITY

GRADES: 4-A*

SUBJECT: Math, Science

SKILLS: Analyzing, comparing, computing, discussing, experimenting, measuring, observing, small group work

DURATION: 1 hour

SETTING: Indoors

KERA ACADEMIC EXPECTATIONS: 1.3, 1.5, 1.8, 2.1, 2.2, 2.8, 2.9, 2.10, 4.2, 5.3, 6.1, 6.2, 6.3

OBJECTIVE:

To study the characteristics of soil components in relation to groundwater movement.

METHOD:

Measure porosity and permeability of sand, gravel, and clay.

MATERIALS NEEDED PER GROUP:

- Gravel - group 1, sand - group 2, clay - group 3
- 2 - 16oz.-32oz. clear soda or water bottles
- Coffee filter
- Graduated cylinder or 2-cup plastic measuring cup
- Permanent markers or masking tape
- Stop watch or watch with second hand
- Calculators (optional)

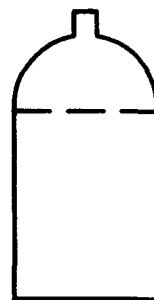


fig. a



fig. b

PROCEDURE:

- Have adult cut off the top third of each soda bottle (fig. a); save both sections.
- Divide class into 3 groups; give each group the materials needed.
- Fill one bottle bottom with a measured amount of water, depending on bottle size. Record amount of water used as the **total volume** of this part of the bottle.
- Place a mark, with marker or tape, at the top of the water. Pour out the water and dry the bottle.
- Fill the bottle up to the mark with gravel, sand, or clay.
- Fill the graduated cylinder or measuring cup to the top line with water and record this amount. Slowly pour the water into the bottle until it just reaches the top of the gravel, sand, or clay.
- Subtract the amount of water that is left in the graduated cylinder or measuring cup from the original amount and record as **pore space** - the volume of water used to saturate or fill the pore spaces of the gravel, sand, or clay.
- Divide the pore space by the total volume to compute the percentage of pore space and record as the **porosity** of the gravel.
- Place top section of the bottle on the bottom (fig. b).
- Fold a coffee filter into quarters, open it into cone and insert into opening, cut off excess.
- Fill the filter with dry gravel, sand or clay to about half an inch from the top.
- Pour a measured amount of water into the sand, gravel, or clay, and record how long it takes for the water to drain into the bottom. This measures the **permeability** of the gravel, sand or clay.

EVALUATION:

This activity illustrates how water moves through the different components of soil and the relationship between porosity and permeability.

- Compare the porosity of the sand, gravel, and clay.
- Which one holds the most water? Why? (large pore spaces)
- Which one holds the least water? Why ? (tiny pore spaces)
- Compare the permeability of the sand, gravel, and clay.
- Which one allowed water to move through it fastest? Why? (more connected pore spaces)
- Which one did not allow water to move through it? Why ? (less connected pore spaces)
- What is the relationship between permeability and porosity? (The larger and more connected spaces between the soil particles, the faster the water moves through it. The smaller and fewer connected spaces between the soil particles, the slower the water moves through it.)

* For Grades K-3 this activity can be done as a teacher demonstration.

(adapted from Cedar Creek Learning Center)



HOW FAST DO SOILS TAKE IN WATER?

GRADES: 4-A*

SUBJECT: Math, Science

SKILLS: Analyzing comparing, discussing, evaluating, graphing, measuring, small group work

DURATION: 30 min. (more depending on soil types and degree of saturation)

SETTING: Outdoors, suitable for use in an outdoor classroom

KERA ACADEMIC EXPECTATIONS: 1.3, 1.8, 2.1, 2.2, 2.9, 2.10, 4.2, 5.1, 5.3, 6.1, 6.2, 6.3

OBJECTIVE: To observe the rate at which various soils absorb water.

METHOD: On-site observation of soil permeability.

MATERIALS NEEDED PER GROUP:

- No. 10 tin can (1 lb. coffee can) open on both ends
- Ruler
- Stop watch
- Quart of water
- Permanent marker or masking tape

PROCEDURE:

- Select several sites around school grounds with different soil types and degrees of wetness: sandy or gravel area, woodland, fence row, grassy field, bare spot, drainage ditch with no standing water, swampy area, heavily traveled area (path), etc.
- Divide the class into several groups, one group per selected site, and give each group the materials needed.
- Mark a line 2 inches from the bottom of the can with marker or tape.
- Push can into the ground to the line at each site (adult may need to help with this).
- Pour a quart of water into each can and record the time it takes for all the water to disappear (start timing as water is being poured).
- Make a chart or graph showing the different sites and the time it took for the water to disappear.

EVALUATION: This activity illustrates how water is absorbed by soil (permeability) and the relationship between soil saturation and surface runoff.

- Which site had the fastest time? Why?
- Which site had the slowest time? Why?
- What were the soil characteristics at each site? (degree of wetness, type of soil, etc.)
- Did any site have surface runoff? Why or why not?

EXTENSIONS: Use a soil probe or shovel at each site to remove a sample of soil; compare the color, texture, and composition of the samples from each site.

- How does soil composition affect permeability?

* For Grades K-3 this activity can be done by the class as a whole or as a teacher demonstration

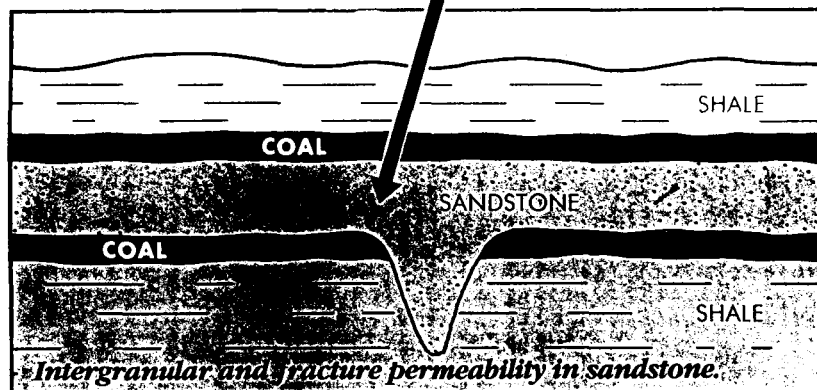
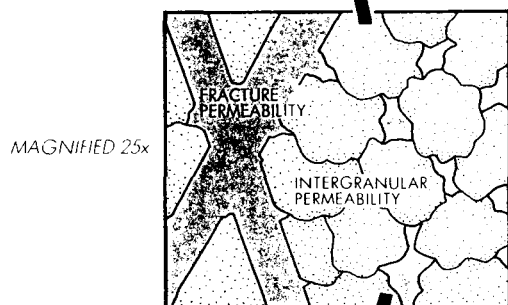
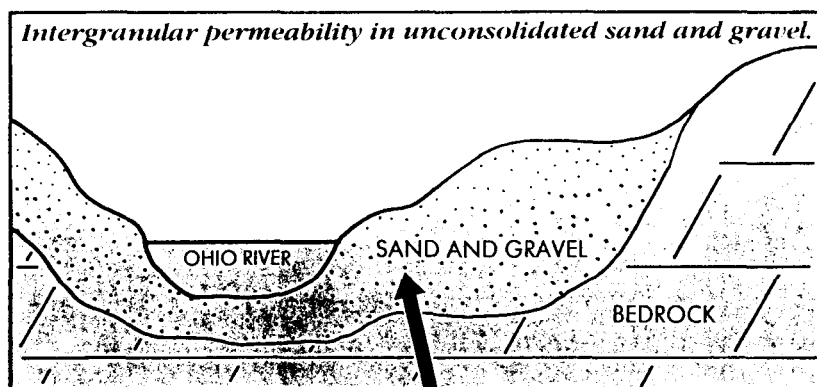
(Adapted from Soil and Conservation Service, 1986)

GROUNDWATER AND KARST

Most Kentuckians get their water from lakes and rivers. Only 20 percent get theirs from groundwater even though it makes up more than 95 percent of all the freshwater resources in the state (Groundwater Branch).

Groundwater is water that soaks into the soil and is stored in the saturated zone where it fills the spaces between the soil particles and in cracks in the rocks. The layers of rock and soil that can contain appreciable amounts of water are called aquifers and anytime that water soaks into the ground it recharges (adds to) the aquifers. Limestone, sandstone, and uncemented sediments such as sand and gravel are the major types of aquifers in Kentucky (Cole and Pauley, 1993; Trautman, Porter, and Wagenet, 1985; Janowicz, et al., 1991; Kentucky Division of Water, 1991).

OHIO RIVER VALLEY AND MISSISSIPPI EMBAYMENT



EASTERN AND WESTERN COALFIELDS
(adapted from Kentucky Cooperative Extension Service, 1990)

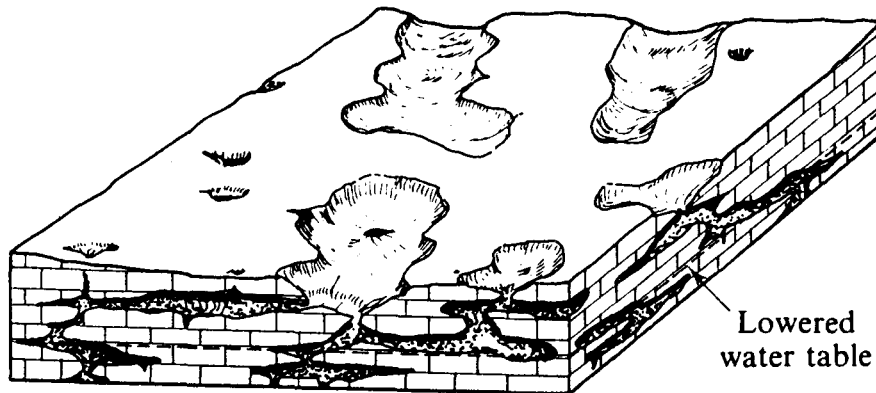
Sandstone aquifers occur in 30 percent of Kentucky, primarily in the Western and Eastern Coalfield Regions. The water is stored in the open spaces between the sand grains in the rock as well as in any cracks and joints.

Uncemented sediments such as sand and gravel form large aquifers in the Mississippi Embayment Region. Smaller aquifers of this type are found in river bottoms throughout the state.

The soil layer is usually thick over these two types of aquifers. Thus water infiltrates slowly into the ground and the flow of water through the aquifer is measured in inches per year (Mammoth Cave National Park; Janowicz, et al., 1991).

Limestone or karst aquifers are found in 55 percent of the state in the Bluegrass and Mississippi Plateau regions. Karst is a landform that occurs when carbonate rocks such as limestone are present at the earth's surface. It is characterized by solution features such as caves and sinkholes. These features form when water percolating through acidic soils dissolves the limestone along fractures and between rock layers creating

BLUEGRASS AND MISSISSIPPI PLATEAUS



(Foster, 1971)

solution channels. The solution channels enlarge and collapse to form sinkholes at the earth's surface and caves underground. The soil layer is usually thin in limestone aquifers, thus water infiltrates quickly into the ground and water flow is measured in feet per minute through the rock cavities (Mammoth Cave National Park; Janowicz, et al., 1991, Kentucky Division of Water, 1991).

Because rivers and streams are the surface expression of groundwater, any pollution entering one will contaminate the other. Also, sinkholes and solution channels act like nature's storm drains and storm sewer systems by channeling runoff to the groundwater. Any household or community waste dumped into sinkholes immediately pollutes the groundwater in the solution channels (Cole and Pauley, 1993; Mammoth Cave National Park; American Cave Conservation Association, 1995; The American Groundwater Trust, 1991).

The main sources of groundwater pollution include:

- unplugged oil and gas wells
- malfunctioning septic systems
- leaking underground storage tanks and landfills
- open dumps and hazardous waste sites
- excessive application of farm chemicals
- trash dumped into sinkholes

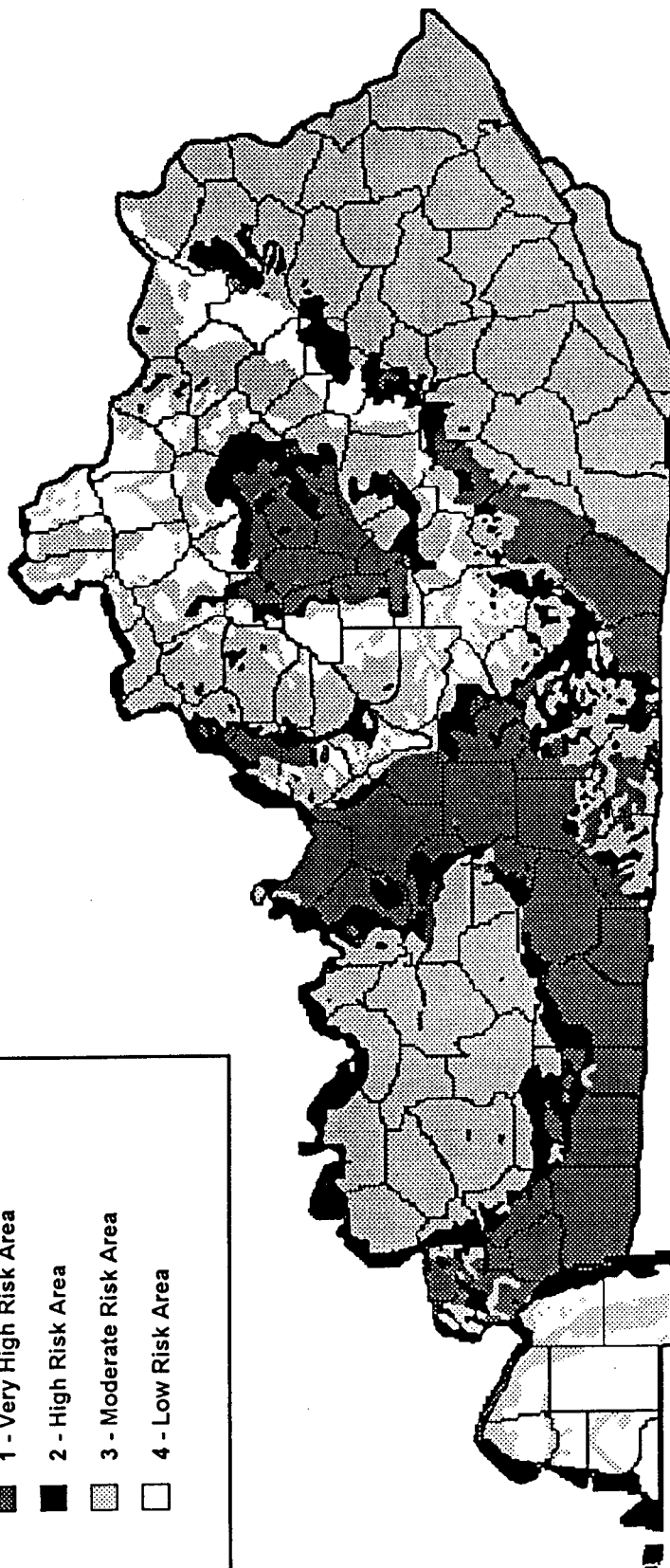
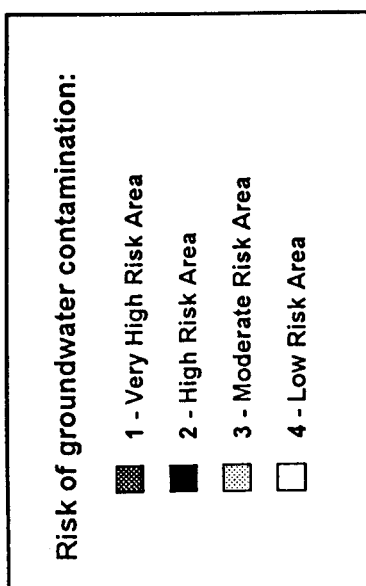
(Wunsch, Carey, and Dinger, 1993)

To prevent pollution of the groundwater:

- dispose of trash in landfills, not in sinkholes
- plant buffer zones around sinkholes
- properly apply farm and lawn chemicals
- maintain septic systems
- remove leaking underground storage tanks and surrounding soil
- monitor landfills for leaking fluids
- clean up open dumps, sinkholes, and hazardous waste sites
- cap abandoned oil, gas and water wells
- a groundwater protection plan is now required in most areas of Kentucky

The following activities illustrate how water moves through the ground.

Groundwater Sensitivity Map



Reproduced from map created by Division of Water - Groundwater Branch : Frankfort, Ky.

This map shows the potential of groundwater contamination in the different areas of Kentucky. Find the county you live in to determine how sensitive your region is to groundwater contamination.



GROUNDWATER

GRADES: K-8

SUBJECT: Math, Science

SKILLS: Counting, discussing, estimating, experimenting, hypothesizing, observing, predicting, small group work, visualizing

DURATION: 30 minutes

SETTING: Indoors

KERA ACADEMIC EXPECTATIONS: 1.3, 1.8, 2.1, 2.4, 2.9, 2.10, 4.2, 5.3, 6.3

OBJECTIVE:

To demonstrate that the ground can hold water.

METHOD:

Count how many spoonfuls of water is needed to saturate a container of sand.

MATERIALS NEEDED PER GROUP:

- 2 clear plastic cups
- Sand
- Teaspoon
- Water

PROCEDURE:

- Divide class into groups and give each group the materials needed.
- Pour any amount of dry sand into one of the plastic cups.
- Fill other cup with water to the same level as the sand.
- Hypothesize as to how many spoonfuls of water will be needed to saturate the sand. (When water comes to the top of the sand.)
- With spoon, transfer the water to the sand until the sand is saturated.
- Record how many spoonfuls of water was used.

EVALUATION:

This activity demonstrates that the ground can store water.

- Which group was the closest to the predicted amount?
- How is the water stored in the sand? (In-between the sand grains)

(adapted from Hirschland, 1992)



AQUIFERS

GRADES: 4-A*

SUBJECT: Math, Science

SKILLS: Analyzing, comparing, experimenting, measuring, observing, small group work

DURATION: 30 minutes to set up, several hours or over night to observe

SETTING: Indoors

KERA ACADEMIC EXPECTATIONS: 1.3, 1.8, 1.10, 2.1, 2.2, 2.9, 2.10, 4.2, 5.2, 6.1, 6.3

OBJECTIVE:

To observe how some rocks can act as aquifers.

METHOD:

Measure how much water different types of rocks absorb.

MATERIALS NEEDED PER GROUP:

- Water
- Container
- Sedimentary rock (sandstone, limestone, shale, conglomerate, siltstone, etc.)
- Measuring cup or graduated cylinder
- Plastic wrap

PROCEDURE:

- Pour a measured amount of water into container.
- Add the rock (water need not cover rock).
- Cover container with plastic wrap to prevent evaporation.
- Let sit for several hours or over night.
- Measure and record how much water is left.

EVALUATION:

This activity demonstrates which rock type can act as an aquifer.

- Which rock absorbed the most water? Why? (high permeability)
- Which rock absorbed the least amount of water? Why? (low permeability)
- How could water be stored in the less permeable rocks? (in cracks and crevices)

* For Grades K-3 the students can put drops of water on different types of rocks to see which rocks absorb the drops.

(adapted from National Vocational Agriculture Teachers Association)



GROUNDWATER MODEL

GRADES: 4-A

SUBJECT: Science

SKILLS: Applying, analyzing, observing, small group work, visualizing

DURATION: 1 hour

SETTING: Outdoors

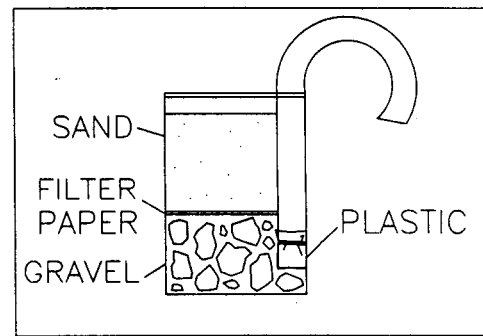
KERA ACADEMIC EXPECTATIONS: 1.3, 2.1, 2.2, 2.3, 2.4, 2.9, 4.2, 5.3, 6.3

OBJECTIVE: To gain an understanding of the movement of groundwater and what happens when it is polluted.

METHOD: Build a groundwater model.

MATERIALS NEEDED PER GROUP:

- 1 - 20 oz. clear plastic glass
- 18" length of aquarium tubing
- 2" square of cut-up panty hose
- Rubber band
- Masking tape
- Small pebbles
- Sand
- 3" circle cut from coffee filter
- Water
- Red food coloring
- Syringe (optional)



PROCEDURE:

- Divide class into groups and give each group the materials needed.
- Place panty hose square over one end of tubing and secure with rubber band.
- Tape hose-covered end of tubing to inside of glass.
- Fill glass 1/3 full of pebbles, and place filter paper on top of pebbles, cutting filter to fit.
- Fill almost to the top with sand, and add enough water to saturate the soil and pond on top of the sand.
- Use the syringe to siphon some water through the tube. OR, fill the hose with water, hold a finger over the end and siphon off the water a little at a time by removing finger and allowing water to flow out the tube.
- Add a few drops of food coloring to the sand to represent pollution and continue pumping (may need to add more water).

EVALUATION: This activity shows how groundwater can become polluted.

- How is water moving through the model? (Through the pore spaces in the sand and gravel)
- What happens to the food coloring?
- What would this represent in real life? (Polluted well)

(adapted from Florida Cooperative Extension Service; Hirschland, 1992)



SODA SINK

GRADES: 4-A*

SUBJECT: Science

SKILLS: Comparing, discussing, experimenting, inferring, interpreting, observing, predicting, small group work, visualizing

DURATION: 1 hour

SETTING: Indoor

KERA ACADEMIC EXPECTATIONS: 1.3, 1.8, 2.1, 2.2, 2.3, 2.4, 2.9, 2.10, 4.2, 5.1, 5.3, 6.2, 6.3

OBJECTIVE:

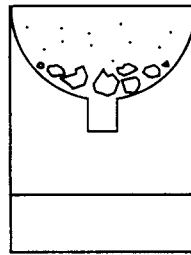
To gain an understanding of how water flows underground.

METHOD:

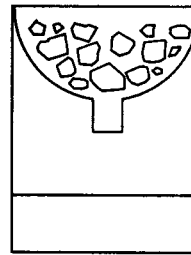
Construct three models showing different types of groundwater flow.

MATERIALS NEEDED PER GROUP:

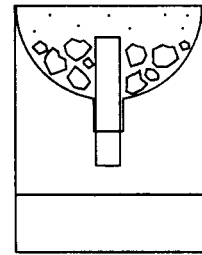
- Two 2-liter clear plastic soda bottles
- Gravel - 1/2" to 1" in diameter
- Soil
- Measuring cup
- Water
- Scissors
- Soda straw
- Stop watch (optional)
- Beets and beet juice



A



B



C

PROCEDURE:

- Have adult cut two inches off the bottom of first bottle - discard bottom. Cut 3" off the top of the other bottle - discard top. (for each group)
- Divide class into three groups A, B, and C. Give each group the materials needed.
- Turn the large top section upside down into the large bottom section. Label the groundwater models according to group letter.
- Fill bottle "A" with an inch of gravel and then 4" of soil. This model demonstrates how water filters down through soil particles.
- Fill bottle "B" half full with gravel. This model demonstrates how water flows through cracks and fractures in rock.
- Insert a straw through the neck of bottle "C", pour 4" of gravel around it so that the gravel is level with the top of the straw. Then add 3" of soil over the gravel and the straw. This model demonstrates how water flows through sinkholes in karst areas.
- Pour a measured amount of water slowly into each model. Record how fast the water percolates through.
- Add a few beets and beet juice to the models to represent trash.
- Pour a measured amount of water slowly into each model. Record percolation rate and color of water in the bottom.

EVALUATION:

These models demonstrate the different rates of groundwater flow and show how susceptible karst areas are to pollution.

- In which model did the water flow fastest?
- In which model did the water flow slowest?
- What happened in model C?
- Which model is more susceptible to groundwater contamination?
- Which model is typical of the groundwater flow in the local area?

* For Grades K-3 this activity can be done as a teacher demonstration.

(Adapted from Mammoth Cave National Park; Western Kentucky University, TVA, and Kentucky Natural Resources and Environmental Protection Cabinet, 1992)

OTHER RESOURCES

GRADES:

- K - 5** Mammoth Cave National Park, unpublished, Clay Caves: Mammoth Cave National Park Environmental Education, KERA and the Cave, pp. 39-43.
Make caves out of sugar cubes and clay.
- 4 - A** Passero, R. N., A Simple, Inexpensive Ground water Flow Model: Western Michigan University, Institute for Water Sciences, G.E.M. Regional Center, 9p.
Build your own groundwater model.
- 6 - A** The Watercourse and Council for Environmental Education, 1995, Get the Groundwater Picture: Project WET, pp. 136-143.
Identify parts of groundwater system, compare movement of water through diverse substances, create a geologic cross section, relate various land uses to potential groundwater contamination.
_____, The Pucker Effect: Project WET, pp. 338-343.
Observe how groundwater transports pollutants and simulate testing to discover the source of contaminants.
- 9 - A** The National Vocational Agriculture Teachers Association, Unit 3 - Contamination of Groundwater: A Hidden Treasure, Instructional Materials for Groundwater Resource Protection, 27pp.
Identify contaminants in groundwater.